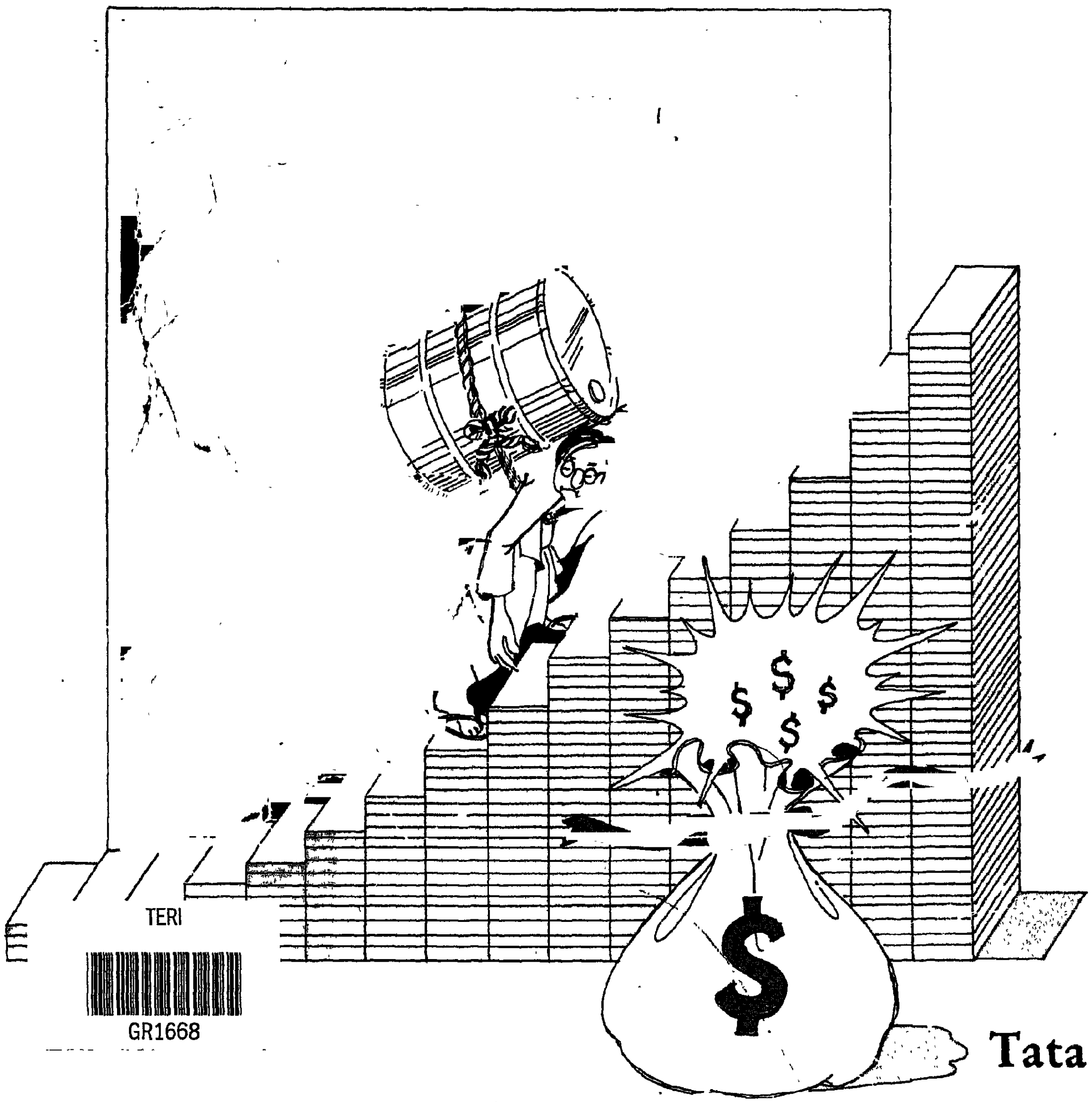
Getting off this 'Fuelish' path



TERI
GR1668

Tata Energy Research Institute

The Governing Council of TERI

Chairman : **Mr. D. S. Seth**
Chairman
Tata Chemicals Ltd
Bombay House
24 Homi Mody Street
Bombay - 400 001

Members : **Dr. A. Ramachandran**
Executive Director
United Nations Centre for Human Settlements
P.O. Box 30030
Nairobi
Kenya

Prof. B. V. Sreekantan
Srinivasa Ramanujam Professor
Tata Institute of Fundamental Research
Bombay - 400 005

Mr. F. C. Kohli
Director-in-charge
Tata Consultancy Services
Air India Building
Nariman Point
Bombay - 400 021

Mr. R. N. Tata
Chairman
Tata Industries
Bombay House
24 Homi Mody Street
Bombay - 400 001

Mr. R. K. Sharma
Secretary to the Government of India
Dept of Non-conventional Energy Sources
Block 14, C.G.O. Complex
Lodi Road
New Delhi - 110 003

Dr. L. M. Singhvi
President
India International Centre
40 Max Mueller Marg
New Delhi - 110 003

Dr. M. S. Swaminathan
Hony. Director
Centre for Research on Sustainable Agricultural and Rural Development
11, Rathna Nagar
Teynampet
Madras - 600 018

PREFACE

The Tata Energy Research Institute (TERI) is a non-profit autonomous institution working on various aspects of energy. The Institute has the privilege of working closely with ministries and departments of the Government of India, particularly those dealing with energy, science and technology, environment and forests and biotechnology. Over the years, TERI has not only developed a large database on the energy sector but has been carrying out a range of analytical studies on current energy policy and future options. The TERI Energy Economy Simulation and Evaluation (TEESE) model is an extensive and rigorous model which has been developed over several years and tested for evaluating energy policies within a quantitative framework. The Institute's charter requires dissemination of research results freely to all who may benefit from them.

We are at a juncture of our development when we need to take a hard and close look at the directions of our present energy policy (or the lack of it), and see how we should reorientate this in the future. And it is in the spirit of informing the public and our decision makers that this brief publication is being disseminated. We hope the analysis presented and the path advocated would lead, at least, to a serious debate from which an enlightened energy policy would be articulated for the country. This report and the analysis contained in it has been authored by my colleagues Mrs. Leena Srivastava and Ms Sujata Gupta with valuable assistance from Mrs. Rita Nangia also. Several other members of TERI's professional staff have contributed to the effort that has gone behind this publication. This is intended as the first of a series of documents to follow on issues of critical importance to India's energy sector and indeed to the future welfare of Indian society.

R K Pachauri
Director

OUR FUELISH WAY

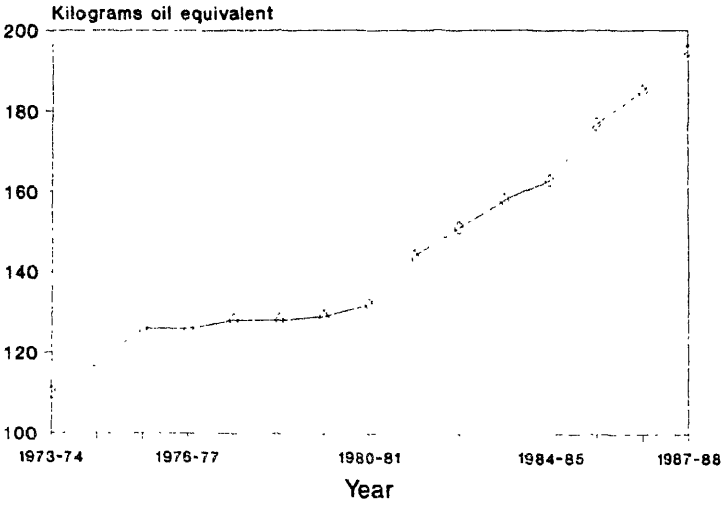
Growing concern has been expressed recently, both within the Government and the media, on India's rising oil import bill. There is talk of petrol rationing and harsh measures to curb consumption of petroleum products. But the problem lies deeper and cannot be solved by administrative measures like rationing and mandatory allocations. India has already spent, in cumulative terms since 1973, more foreign exchange on oil imports than our current external debt. The rapidly rising demand for petroleum products would not only take us in a direction which would lock us into an oil intensive development pattern but also mortgage the country's future through an increasing burden of foreign debt.

Every committee dealing with energy in the past has advocated the importance of reducing oil imports not only for economic but also for strategic reasons. The trend unfortunately has been quite the reverse. Oil consumption and imports are running ahead of projections made only recently by the Energy Demand Steering Group of the Planning Commission and earlier by the Working Group on Energy Policy. The time to act, therefore, is now.

PAST TRENDS AND PATTERNS

Per Capita Commercial Energy Consumption: Per capita commercial energy consumption levels in India are low as compared to those in some of the developed countries whose consumption falls in the range of 3000 to 9000 kg of oil equivalent (kgoe) per capita. However, our per capita consumption has been increasing rapidly and has gone up by 80% in the period 1973-74 to 1987-88 from a level of 110 kgoe per capita to 195 kgoe per capita. Consequently, we are unable to meet demands through domestic resources and have to resort to high levels of imports, so far restricted to oil, resulting in a heavy drain on our foreign exchange resources.

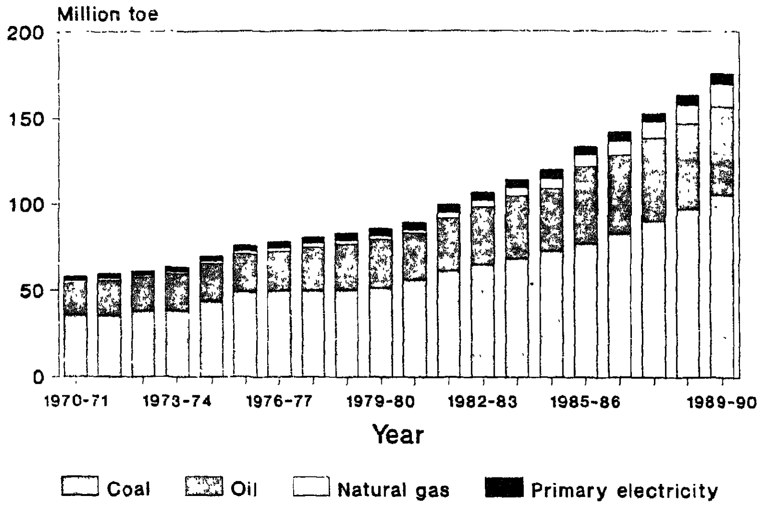
Per capita commercial energy consumption



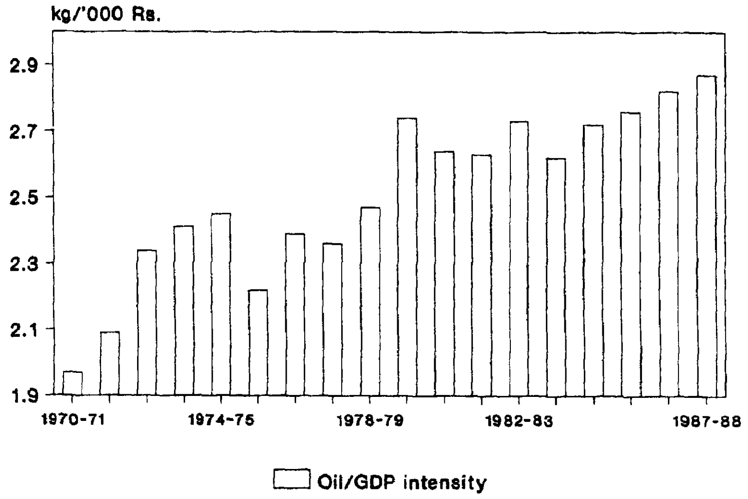
Trends in Energy Consumption: Total energy consumption has increased by a factor of three between 1970-71 and 1989-90. In line with our resource endowments, a large part of this consumption is in the form of coal.

Oil Intensity of Gross Domestic Product: The increasing share of oil in total energy consumption has led to a steady increase in the intensity of gross domestic product from a level of approximately 1.97 kg of oil per 1000 rupees of gross domestic product to 2.87 kg per 1000 rupees of gross domestic product over the period 1970-71 to 1987-88.

Trends in energy consumption



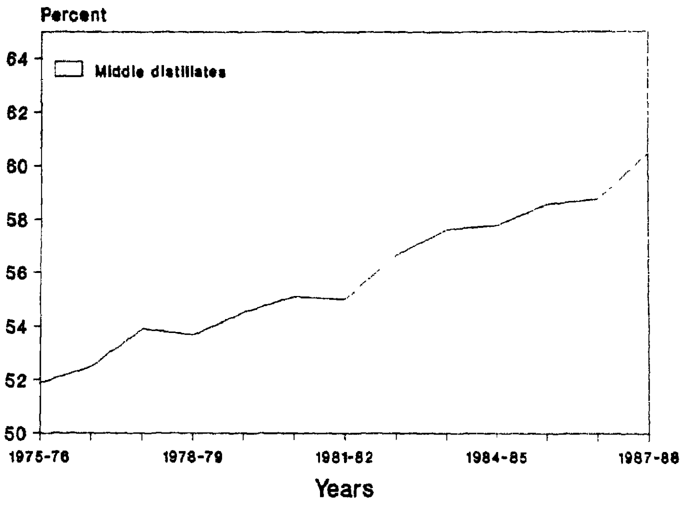
Oil intensity of Gross Domestic Product



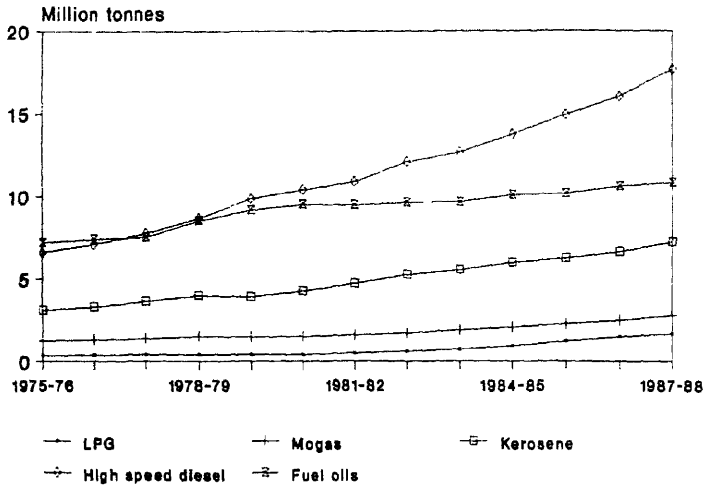
Petroleum Product Consumption Pattern: Unbalanced infrastructural development leading to a rapidly expanding road transport sector and distortions in energy pricing policies have resulted in a disproportionately large demand for middle distillates comprising high speed diesel and kerosene oil. Given the current pattern of refinery outputs we have been faced with large imbalances between the supply and demand for middle distillate products which account for the bulk of our petroleum product imports.

In absolute quantities, the demand for fuel oils is larger than that of kerosene. However, demand for diesel and kerosene are continuing to increase at a rapid pace, while fuel oil demand has more or less stabilized in the 1980s. Another product which has been experiencing high rates of growth recently is LPG.

Share of middle distillates in total oil consumption



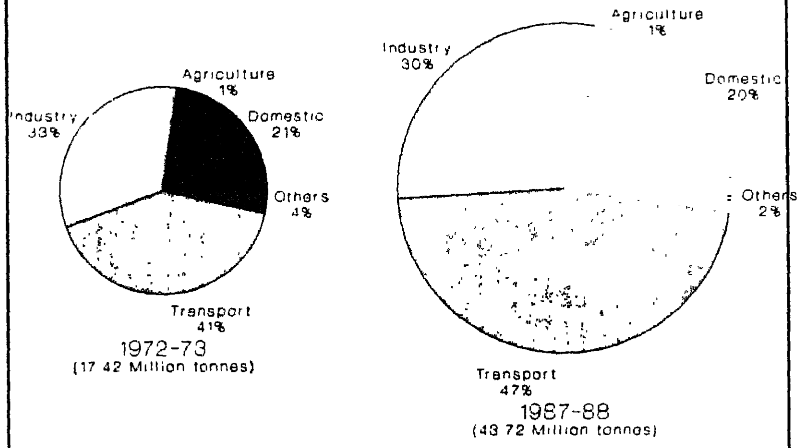
Trends in petroleum product consumption



SECTORWISE PETROLEUM PRODUCT CONSUMPTION

The transportation sector has historically accounted for the bulk of petroleum product consumption. Its share in 1972-73 was 41 per cent and has increased to a level of 47 per cent in 1987-88. This is followed by the industrial sector whose share in petroleum product consumption has been in the range of 30-35 per cent. The domestic sector has been accounting for approximately 20 per cent of oil consumption.

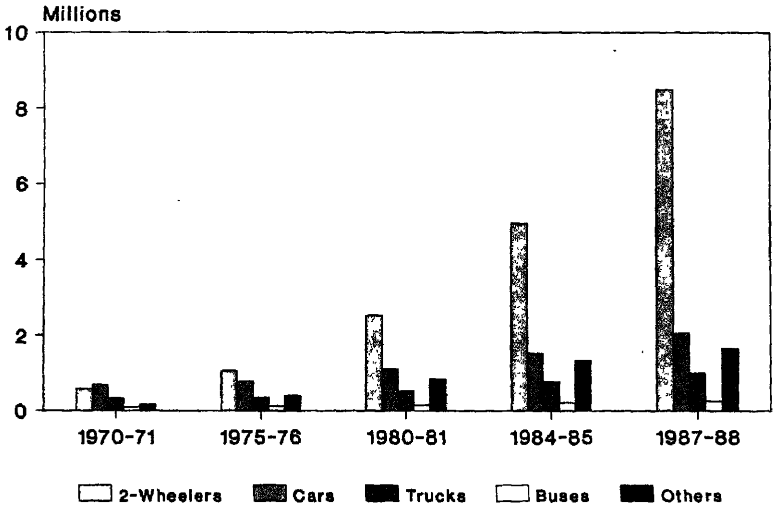
Petroleum product consumption - sectorwise



GROWTH IN TRANSPORT FLEET

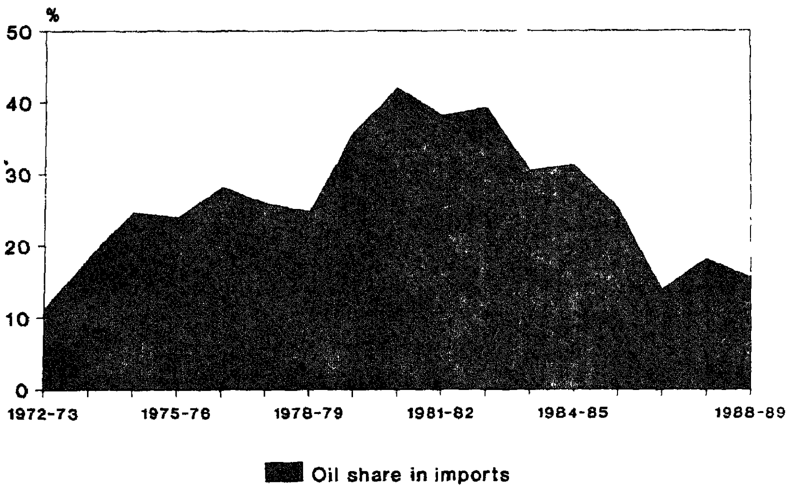
An analysis of the growth in our road transport fleet reveals that there has been a rapid increase in the numbers of all modes of transportation. Increase in the share of road transportation has been due to limited development and insufficient investment in other modes of transportation like railways and waterways. Whereas the growth has been maximum in the case of two wheelers whose population has increased by a factor of 15, growth in the volumes of other modes of transport such as cars, jeeps, taxis, trucks and buses has also been significant and their number had increased by a factor of three by 1987 over the levels of 1970. Other vehicles such as three wheelers, tractors, etc. have also registered a sharp increase in population. As a result of this rapid increase in road-based transport - in particular two and three wheelers - we have now started importing motor spirit in significant quantities as well.

Growth in transport fleet



Share of Oil in Total Imports: The decreasing dependence on oil imports and the increasing import bill (net of oil) should, in total, have resulted in a decline in oil's share in the total import bill. To the contrary, the total value of imports increased rapidly in the period 1975-86, largely due to the two oil price shocks that were experienced in 1973-74 and 1979-80. On the other hand, despite lower levels of self sufficiency in oil in the eighties, falling international prices in the latter half of the 1980's have pulled down the share of oil in total value of imports. However, these low levels of international oil prices are not expected to be sustained over a long period while the quantity of oil imports is on the increase. Hence, we must be prepared for the eventuality of hardening oil prices on the international market and future oil price shocks.

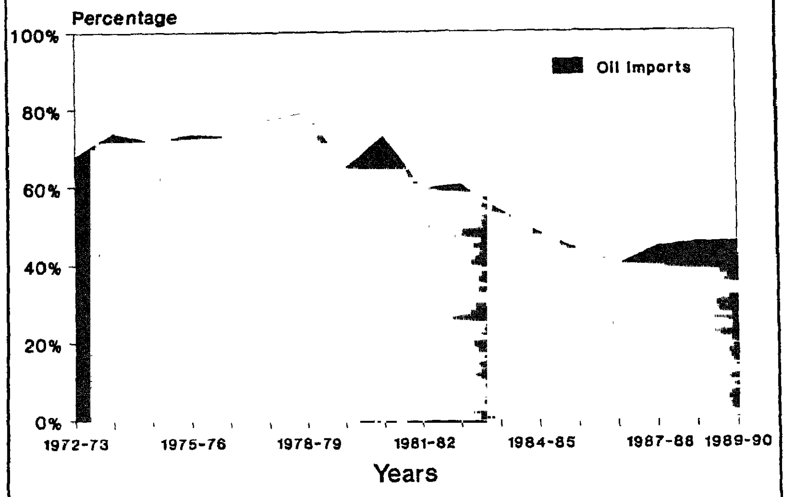
Share of oil in total imports



OIL IMPORTS IN TOTAL OIL CONSUMPTION

While India's oil import dependence in the early 1970's was extremely high--in the range of 70 to 80 per cent--this dependence declined following the discovery of Bombay High in 1975. Subsequently there was a steady decline in dependence on oil imports to a level of 35 per cent in 1986. However, with the rapid growth in oil demand in recent years,the oil import dependence shows an increasing trend. India should consider itself fortunate on two issues: (i) the discovery of domestic reserves in the 1970s leading to a reduction in oil import dependence levels and (ii) the sharp fall in international prices of petroleum in the mid-eighties. If it were not for these two factors, the balance of payments deficit that the country is now facing would have been unmanageable.

Oil imports in total oil consumption

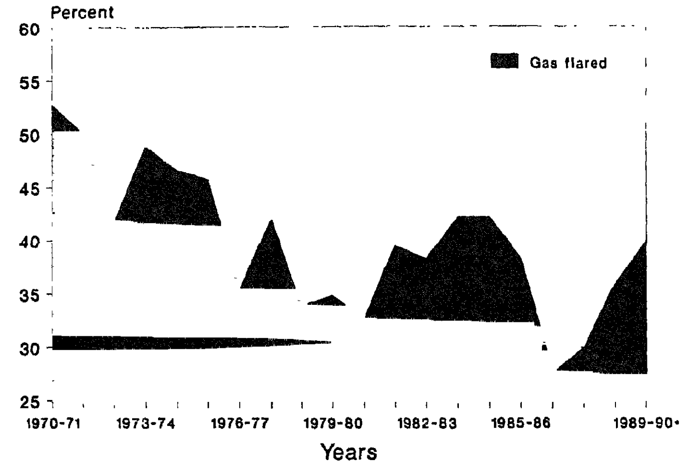


NATURAL GAS

Natural gas is a relatively new entrant in the energy sector in India. Before the discovery of free gas fields at South Bassein, production of natural gas was largely in the form of "associated gas" and linked to crude oil production. Oil companies paid little attention to its use or to the development of markets. As a result, till the mid seventies, almost 50 per cent of gas produced was flared.

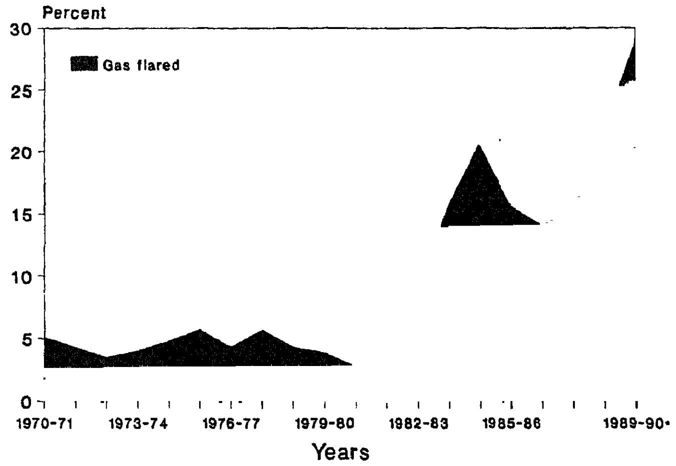
The two oil price shocks and the resulting oil crunch led to increasing pressures to develop natural gas as a resource. As a measure of caution, gas was reserved for "priority" uses, i.e. largely as feedstocks for fertilizers and petrochemicals, where gas generates maximum "economic value". This approach however, failed to take into account inherent uncertainties, e.g., higher gas oil ratios, delays in infrastructure and market development and project implementation. All these have led to a situation where India is at present still flaring nearly 40% of natural gas produced, valued at over Rs.1000 crores per year (in 1989-90 prices). This criminal waste is taking place at a time when policy makers are actually thinking of adopting draconian measures such as 'petrol rationing' to save foreign exchange.

Natural gas flared relative to gross production



• Estimated

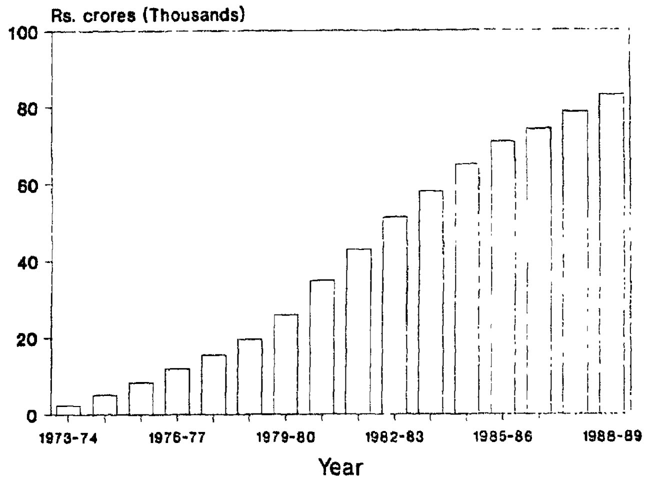
Natural gas flared relative to oil imports



• Estimated

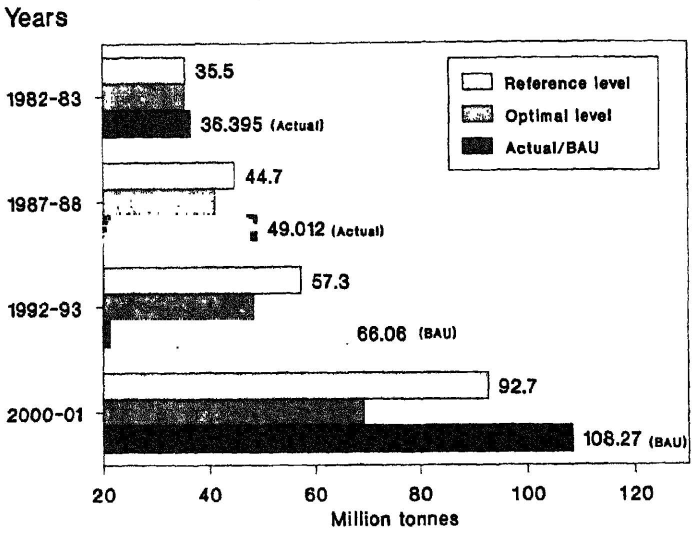
Cumulative Outflow of Foreign Exchange :Petroleum imports in 1988-89 reached 24.07 million tonnes and are estimated at 26.74 million tonnes in 1989-90. The immediate short term projection for the year 1990-91 places gross imports at 31.5 million tonnes. With oil prices already hardening in the international market the foreign exchange burden of oil imports is likely to increase rapidly in the near future. The cumulative outflow of foreign exchange for oil products in the 15 year period 1973-74 to 1988-89 would provide an indication of the total volume of this burden. The total outflow of foreign exchange on this account has been approximately 82000 crores of rupees - equivalent to 45 per cent of the total 7th Five Year Plan outlay and far in excess of our current foreign debt.

Outflow of foreign exchange for POL (in 1988-89 prices)



Projections Vs Actuals: Several exercises have been carried out on estimating energy consumption in the future. The most recent of such exercises on which comparisons with actuals are possible over a reasonable period are those of the Working Group on Energy Policy. This Group came out with two sets of estimates : (1) The reference level forecasts which can be looked upon as a business as usual scenario and (2) the optimal level forecasts based on estimates of energy demand if the Working Group's recommendations on energy efficiency improvements, conservation and fuel substitution were to be implemented. For the first two periods of the WGEP's forecasts, for which now we do have actual data, it is seen that actual oil consumption turned out to be significantly higher than even the reference level forecasts. For the later time periods we have compared the Working Group's results with the business as usual scenario which is described later in these pages.

Actual oil consumption vs. W G E P estimates



THE FUTURE

The rapid increase in demand for commercial energy on the one hand and the relatively low per capita consumption levels on the other would lead us to believe that commercial energy supplies in the future would have to grow at a rapid rate. The question that arises is : To what extent can this demand be met through the exploitation of domestic energy sources?

Demand for different forms of energy has been estimated for the year 2009-10 under three different scenarios. Whereas the business as usual scenario is a mere projection of present trends, the low conservation and high conservation scenarios present the results of optimization exercises based on the TERI Energy Economy Simulation and Evaluation (TEESE) model assuming a set of definite measures in conserving energy and exploiting, to a greater extent, renewable resources.

THE TEESE MODEL AND ASSUMPTIONS MADE FOR CONSERVATION SCENARIOS

The TERI Energy Economy Simulation and Evaluation (TEESE) model, which has been developed over the last 7 years computes the optimal mix of energy that would be required for meeting the demands arising out of the growth of various sectors of the economy. The model has been set up for the terminal years of the 8th, 9th and 11th Five Year Plan periods. The model is a highly detailed depiction of the Indian economy and the flows of energy within it. It is a very useful tool for assessing impacts of alternative growth patterns and energy policies not only on total energy demand and supply options, their foreign exchange implications but also their environmental impacts. The model has been used to assess impacts resulting from varying the estimates of energy efficiencies of various activities in the economy, choices in interfuel substitution, the introduction of renewable forms of energy and new technologies. The TEESE model has been used here for developing low and high conservation scenarios for the year 2009-10.

It has been officially projected that 45 to 65 million tonnes of oil per annum would be produced by the year 2004-05. Taking 55 million tonnes as the 2004-05 production level, it has been assumed that thereafter domestic oil production will increase at the rate of 5 per cent per annum upto 2009-10 leading to a domestic oil availability of 70 million tonnes.

Non-coking coal availability is expected to be 426 million tonnes by 2009-10. The assumed growth rates in coal production in the 10th and 11th plans are much lower than in the 9th plan due to problems relating to the evacuation of coal, environmental considerations, land acquisition, rehabilitation issues and financial resources.

As regards natural gas it has been estimated that production would be of the order of 85 million cubic metres per day by the turn of this century. However, the major constraint here is the development of markets, the large capital requirements for infrastructure development and, therefore, the utilization of gas. Gas off-take would be 85 million cubic metres per day in the year 2009-10.

The scenarios are based on a 40% premium on foreign exchange.

SCENARIOS FOR 2009-10

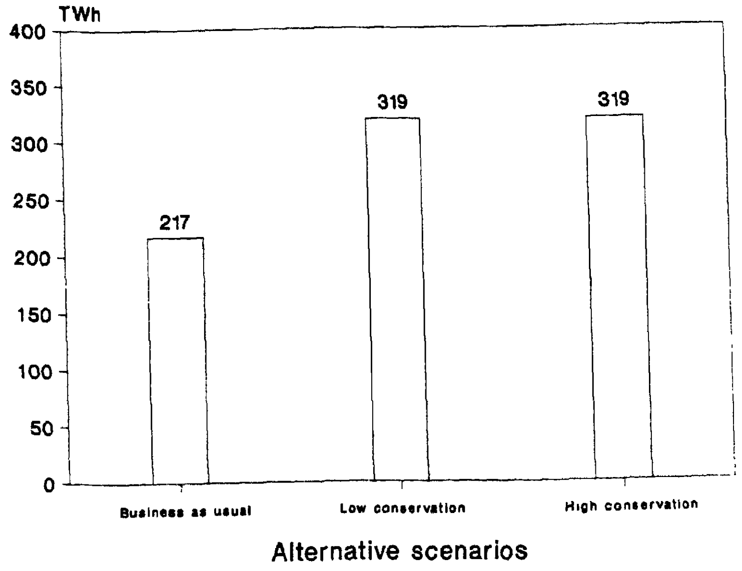
The business as usual (BAU) scenario projects past trends in energy intensities of Gross Domestic Product (GDP) to the year 2009-10 for each primary source of energy. The growth achievements of the Seventh Five Year Plan have led us to assume a future growth in GDP of a reasonable 5 % compound per annum. Energy demand for 2009-10 is estimated as the product of the projected energy intensities and economic output in 2009-10. The implicit assumption here is that no conservation measures would be adopted other than current trends and the share of commercial energy per unit of GDP continues to rise at present rates. The total commercial energy demand in this scenario works out to a stunning 600 mtoe in 2009-10.

The low conservation scenario incorporates the options of cogeneration and PV for lighting in rural areas. Efficiency of thermal power stations is assumed to improve to 33 per cent, and transmission and distribution losses are taken at 18 per cent. Growth in diesel based rail movement has been assumed at 5 per cent per annum and the option of importing non-coking coal has also been included. Total energy consumption in this model works out to 446 mtoe in 2009-10.

The high conservation scenario includes the options of wind power and solar power for base electricity generation, solar hot water systems and solar cookers. It is assumed that improvements in the power transmission and distribution systems will result in a decline in T&D losses to 15 per cent. Further, the national improved cookstoves programme is expected to bring up the efficiency of firewood stoves to 18 per cent. Capacity expansion programmes of the Railways are expected to result in a growth rate of 6% per annum for freight movement. Industrial efficiencies are assumed to increase by 20% in the case of thermal efficiencies and 10% in the case of electricity use efficiency. It is also assumed that the present stagnation with respect to lighting technology development would disappear to allow the introduction of compact fluorescent lighting technology - already in extensive use in developed countries.

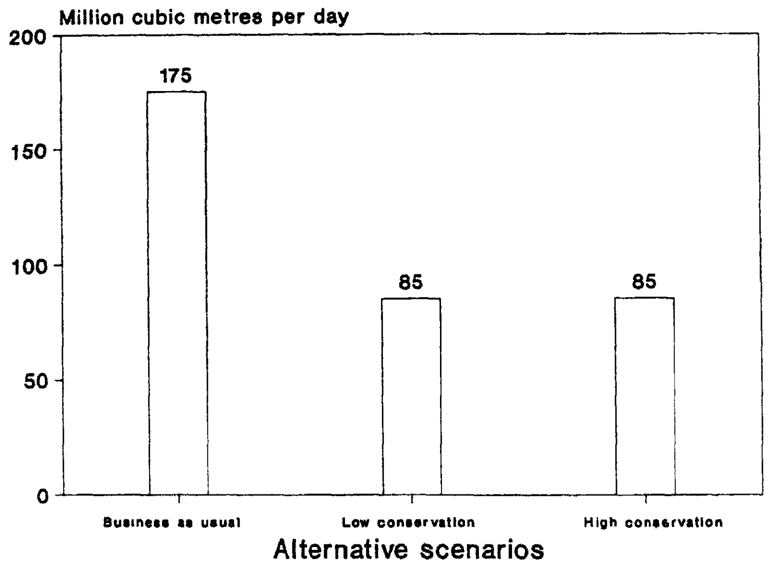
Electricity Demand: Primary electricity demand (Hydro and Nuclear only) as per the business as usual (BAU) scenario is 217 TWh implying a growth rate of about 6 per cent over the period 1988-89 to 2009-10. Primary electricity demand in the conservation scenarios are higher than the BAU scenario due to an assumption of higher growth in nuclear and hydel capacities. Primary electricity generation is stable at 319 TWh because nuclear capacity has been limited to 20000 MW and hydel capacity at 65000 MW in 2009-10. Conservation measures have no impact on primary electricity demand as these are at the upper limits of their availability, but have a significant impact on secondary electricity demand reflected in the demand for coal and shifts in the consumption pattern of natural gas.

Primary electricity demand 2009-10



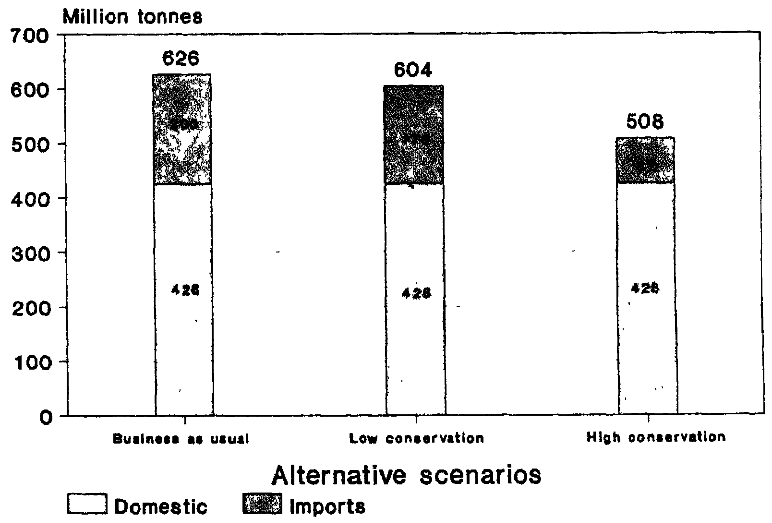
Natural Gas Demand Scenarios: If the rapid growth in the utilization of natural gas in the last few years and the resultant intensity of its use are expected to continue in the future the demand for natural gas would skyrocket to 175 million cubic metres per day, requiring gigantic levels of investments in infrastructure and market development. Hence we have limited natural gas availability to a manageable level of 85 mcm per day in 2009-10.

Natural gas demand
2009-10



Non-coking Coal Demand: Total demand in the business as usual scenario works out to 626 million tonnes. Going by our assumptions on likely availability of coal, this would work out to an import level as high as 200 million tonnes if energy demand has to be met. The low conservation scenario has a marginal effect on total non-coking coal demand reducing imports by 22 million tonnes. The high conservation scenario has a very significant impact on coal demand bringing down the import levels to 82 million tonnes. A large part of this decline

Non coking coal demand
2009-10

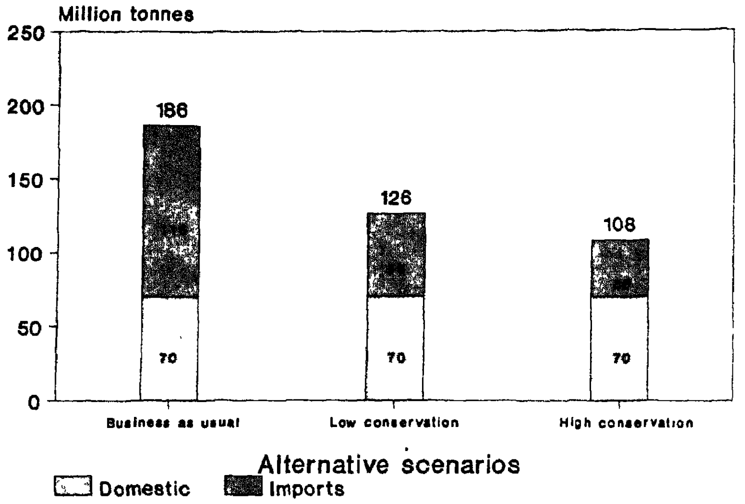


is due to reduction in industrial usage of non-coking coal.

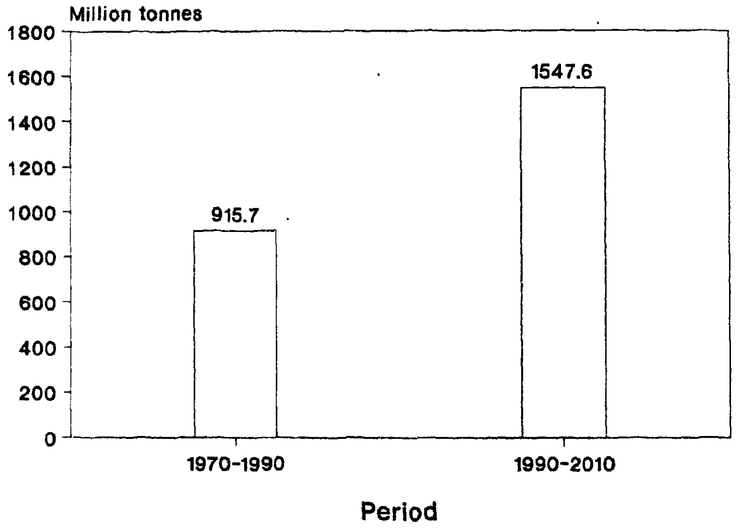
Oil Demand Scenarios: The business as usual scenario indicates an impossibly high level of demand for petroleum products at 186 million tonnes. This would imply that import of POL products would grow at the level of over 7.6% per annum in the period 1989-90 to 2009-10 as against a growth level of 3.2 % in the period 1972-73 to 1989-90. The unsustainability of present trends in the intensity of oil use even assuming a moderate GDP growth of 5 per cent are starkly apparent. As against the business as usual scenario the optimal low conservation scenario indicates an oil demand of 126 million tonnes implying an import level of 56 million tonnes and a rate of present level growth of imports at 3.8 % per annum. The high conservation scenario, which takes into account large scale implementation of renewable energy programmes, is the most desirable approach and would bring down oil demand to 108 million tonnes - very close to the demand projections for the year 1999-2000. However, this would still imply an import requirement of 38 million tonnes of crude oil and products.

Another implication in the oil sector is that the additions to recoverable reserves that would be required in this period in order to be able to sustain the increases in oil production to reach the level of 70 million tonnes by 2009-10 would be in the range of 1550 million tonnes. Thus while in the last 20 years we have cumulatively added 900 million tonnes to our domestic oil reserves, in the next 20 years we would need to increase this to over 1500 million tonnes if we aim to keep the reserves to production ratio constant.

Oil demand
2009-10

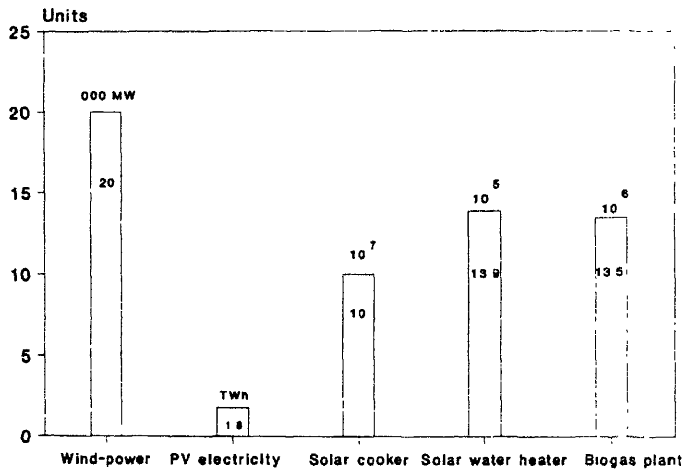


Cumulative additions to reserves



Renewable Energy Options: Demand for conventional energy forms in the high conservation scenario is significantly lower than that in the low conservation scenario partly due to higher efficiency levels in industrial energy use and in the transportation sector and partly because of the large scale utilization of renewable forms of energy. Several organisations and individuals have in recent years been vociferously advocating a much higher use of these non-exhaustible, environmentally benign sources of energy - to little avail. In contrast, the high conservation scenario would exploit a wind potential of 20,000 MW and produce 1.75 TWh through the use of photovoltaics. Solar cookers emerged as economically viable options and the upper limit of penetration of solar cookers which was set at 100 million cookers would be achieved as an optimal solution. In the event that this upper bound on the penetration of solar cookers is removed, it is found that solar cookers would substitute for kerosene to the extent that all imports of kerosene are eliminated. Solar water heating systems are also economically attractive as compared to electricity based heating devices and 1.4 million domestic solar hot water systems are indicated - substituting for electricity use. Biogas plants to the tune of 13.5 million family sized plants are indicated.

Renewable energy sources 2009-10

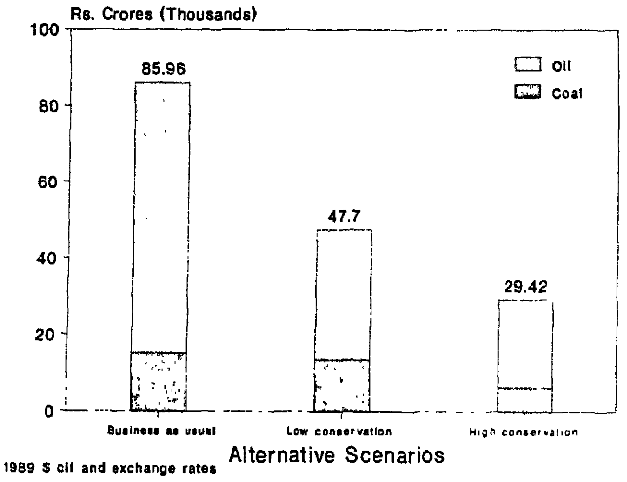


RENEWABLE ENERGY STATISTICS

	Cumulative upto February 1989
Family size Biogas plants	10.96 Lakhs
Improved Chulhas	56.57 Lakhs
Wind Farms	6.85 MW
Domestic Solar Water Heaters	3089 Numbers
Solar Cookers	1.20 Lakhs

Foreign Exchange Implications of Future Energy Demand: Energy demand under the business as usual scenario is quite unsustainable. This point is brought forth forcefully when one looks at the foreign exchange implications of these levels of energy demand. In the business as usual scenario foreign exchange requirements in the year 2009-10 would be close to Rs. 86000 crores in 1989 prices - equal to the cumulative outflow of foreign exchange for oil over the period 1973-88. The conservation scenario brings down these requirements to a level less than 48000 crores of rupees and the high conservation scenario further reduces it to approximately 34000 crores of rupees. Comparing these with the current ceiling placed on outflow of foreign exchange for import of POL products at 7500 crores of rupees for 1990-91, brings out very clearly the need to not only adopt all the measures that have been included in the high conservation scenario but also to identify technology changes, fuel substitution options and alternative fuels for further compressing the burden that the energy sector is likely to place on balance of payments.

Foreign exchange requirements
2009-10



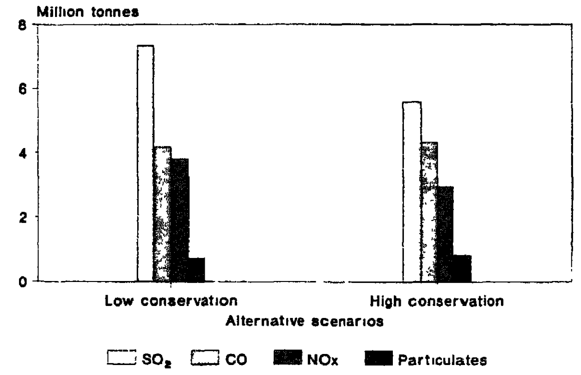
1989 $ cif and exchange rates

THE ENVIRONMENTAL DIMENSION

Increasing energy consumption levels threaten the environmental stability of every society. Fuels consumed in the households, industry and transportation sectors, all add noxious gases to the atmosphere which lead to problems like acid rain and smog. For example, when coal is burnt, not only do we produce heat but we also pollute the surrounding environs with carbon dioxide (CO_2), sulphur dioxide (SO_2), carbon monoxide (CO), nitrogen oxides (NO_x) and particulates.

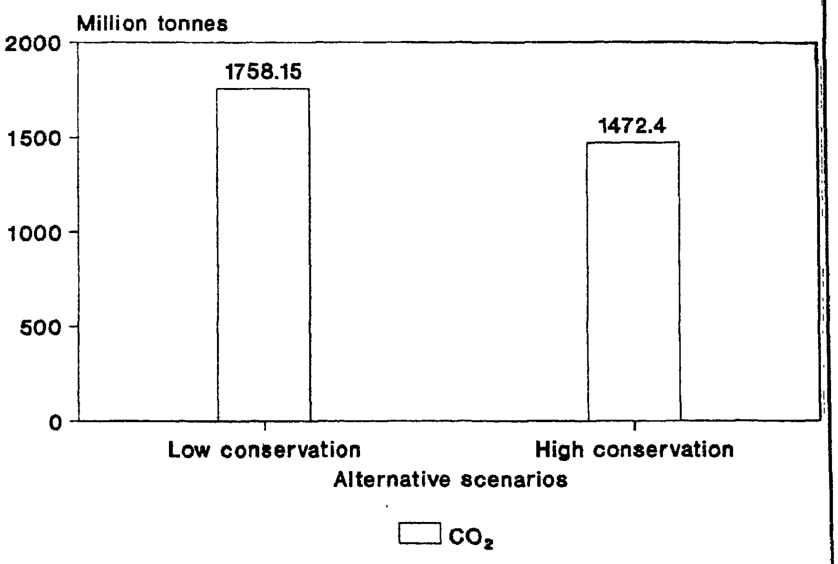
Another major adverse impact of fuel burning relates to the emissions of greenhouse gases which will cause the average temperature of the world to rise in coming decades. There is a growing consensus that global warming would lead to rising sea levels, reduction in fresh water availability, changes in precipitation patterns and higher storm activity. It is true that, with development and growth in the economy, energy consumption would increase. However, this has to be moderated through the use of more efficient and environmentally benign energy technologies and sources. Increased usage of renewable forms of energy like solar and wind and low-cost improvements in efficiency can result in nearly 30 per cent reductions in SO_2 and NO_x emissions. In the optimisation scenarios annual emission of toxic gases are estimated to be four to six times the 1984-85 levels.

Emissions from energy consumption in 2009-10



The contribution of carbon dioxide to global warming has been estimated to be nearly 70 per cent of all greenhouse gases. CO_2 emissions can be reduced by 20 per cent in the high conservation scenario. In the current global negotiations funds should be sought from the developed countries, who have primarily created the greenhouse problem, to help achieve this 20 % reduction in India.

CO_2 emissions from energy consumption 2009-10



GETTING OFF THIS FUELISH PATH

Continuing the present trend is clearly infeasible, and it is therefore, necessary to take several urgent measures to ensure the sustainability of future development. Based on the analyses presented above we would propose:

(1) Strong energy conservation measures be instituted immediately, and, what is more important, a flexible, preferably non-government structure, be developed for implementing a vigorous energy efficient strategy for the country, involving every sector of the economy.

(2) An increase in the commitment of the Government to development of renewable forms of energy. This would need a mission-oriented and coordinated project at the national level to achieve pre-specified goals in technology development and restructuring of organisations to handle renewable energy programmes, particularly at a decentralised level.

(3) Major restructuring of our economic base be initiated urgently, particularly in the case of transportation, so that our growing dependence on road transport is reversed in favour of more energy efficient mass transport systems. This would require investments in public transport, modernisation and expansion of railway services, and greater use of water transport within the country and in coastal areas.

(4) Introduction and enactment of legislation to ensure that decentralized forms of energy generation are treated on par with centralized forms, particularly by requiring electric utilities to pay a reasonable price for power to be generated from sources like wind, cogeneration, and other options for feeding into the grid.

(5) Setting up a high level group to evolve and monitor overall energy policy, similar to the erstwhile Advisory Board on Energy, to minimise the dangers of a fragmented approach to energy as exists currently. This body should have government support at the highest level, but should be based on a flexible autonomous structure which allows it to involve every sector and section of the country in the task of energy policy formulation and evaluation.

(6) [illegible] assessment to see whether the [illegible] structure of the electricity supply industry is viable and capable of meeting the challenges of the future. [illegible] major modifications in the Electricity Supply Act [illegible] become essential to bring about better resource utilisation in the power sector and to ensure greater effectiveness and autonomy of this industry.

The implications of the analysis presented above are unmistakably clear. The fuelish path which we have adopted would lead us into enormous difficulties - even disaster. India cannot sustain the level of oil imports that would be required unless we change directions and adopt a strategy of extensive energy conservation and greater use of renewable resources. The strategy we have presented is based on a vigorous rate of economic growth and aims at increasing the welfare of the population of India. Against this alternative if we continue on the present path the very base of our economic structure would get eroded and economic growth would suffer with an ever mounting oil import bill sucking the country into the debt trap. A reappraisal of our energy policy is, therefore, overdue, and must become the focus of a public debate in the weeks and months ahead. Let us get off the energy treadmill. Let us get off this fuelish path.

ENERGY SITUATION IN INDIA (1988-89)

ELECTRICITY CAPACITY		
HYDRO	17800	MW
THERMAL	39700	MW
NUCLEAR	1600	MW
COAL PRODUCTION	204.04	MT
COKING	42.84	MT
NON-COKING	151.80	MT
LIGNITE	12.40	MT
OIL		
CRUDE OIL PRODUCTION	32.00	MT
CRUDE OIL IMPORTS	17.80	MT
PETROLEUM PRODUCT PRODUCTION	46.40	MT
PETROLEUM PRODUCT IMPORTS	6.30	MT
CONSUMPTION OF PRODUCTS	49.80	MT
LPG	1.96	MT
NAPHTHA	3.33	MT
MOGAS	3.04	MT
KEROSENE	7.71	MT
ATF	1.70	MT
HSD	18.70	MT
LDO	1.40	MT
FO	8.40	MT
NATURAL GAS		
PRODUCTION	13.22	BCM
CONSUMPTION	8.06	BCM